CETRA[2024] 15-17 May 2024, Cavtat, Croatia
8th International Conferenceon Road and Rail Infrastructure

QUIET RAILS: NOISE MITIGATION ON POLISH RAILWAYS

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Abstract

The paper concerns the results of research on the use of different types of noise mitigation measures on railway lines. The main goal of the work was to compare the effectiveness of selected methods used in Poland. The best results were observed when a combination of under sleeper pads and rail dampers was used. Additionally, the relationship between noise reduction and train speed was studied.

Keywords: railway, noise mitigation measures, noise reduction, rail absorbers

1 Introduction

Noise generated by vehicle traffic is well known and recognized as a significant factor negatively affecting daily life. Noise from railway traffic affects more than 22 million people worldwide, proving that it is a global problem, present not only in Poland [1-2]. In recent years, numerous measures have been taken to reduce the negative impact of railway noise on residents. Nowadays in Poland, the main strategy for reducing railway noise is noise barriers, which effectively reduce noise levels. Nevertheless, it is important to point out that noise barriers are not always an optimal solution and, despite their high acoustic effectiveness, have several disadvantages. This solution is mainly focused on protecting people living in noise-exposed areas, but can adversely affect the comfort of traveling passengers and can also pose a potential threat to rail traffic safety. Accordingly, there is a need to explore alternative solutions that can effectively reduce railway noise while also considering aesthetic, functional and economic aspects.

One of the solutions to reduce railway noise is rail lubrication. In addition to reducing the generated noise level, lubrication prevents excessive track and wheel usage, which translates into a longer operating life for these components and reduces maintenance costs for rail infrastructure [3]. Noise reduction using this protection reaches values in the range of 2 - 6 dB [4]. Rail dampers, another type of noise mitigation measure, are installed directly on the rails to absorb and reduce the noise generated by passing trains. Noise reduction with rail dampers can be about 2 - 9 dB [5]. By reducing vibrations, rail dampers reduce sound emissions, which contributes to reducing the annoyance to the surroundings and improving the living comfort of residents near railway lines, as well as increasing the comfort of train travel. It is also possible to reduce noise on railways through methods such as controlling train speeds, upgrading rolling stock or renewing track infrastructure. However, the mentioned methods carry significant economic costs or, in the case of speed reduction, can lead to a decrease in travel comfort.

DOI: https://doi.org/10.5592/CO/CETRA.2024.1734

2 Methods

The aim of the study was to analyze the effectiveness of selected noise mitigation measures used in Poland to reduce railway noise. On the basis of information provided by railway network management institutions, measurement locations were selected where rail absorbers, under sleeper pads, rail dampers or lubricators were applied. For assessment of the noise reduction, it was necessary to conduct in-situ tests, using the same measurement methodology, at each of the selected locations. Measurements were taken at a distance of 7.5 meters from the axis of the railway track at a height of 1.2 meters. At each measurement point, noise measurements were made at two locations: the reference point and the location where the noise mitigation devices were applied. Measurements were carried out simultaneously at both points, allowing direct comparison of sound levels in the presence and absence of acoustic protection. Parameters such as train speed, type of fleet and atmospheric conditions were also taken into account during the study.

3 Results

Based on the results of the study, noise reduction was calculated in areas where acoustic protection was applied. In order to eliminate the speed variable, the values represent the reduction for trains traveling at 80 km/h. The results obtained are summarized in Table 1.

Table 1 Effectiveness of selected noise mitigation measures

Type of noise mitigation measure	**Noise reduction** [dB]
Lubricators	2.9
VICON type rail absorbers	4.2
Under sleeper pads	3.4
Rail dampers	4.3
Under sleeper pads + rail dampers	4.8

The studied noise mitigation measures used in the emission zone were analized, with the observation that the simultaneous use of under sleeper pads and rail dampers provided the greatest noise reduction, reaching 4.8 dB. According to the results of other studies, noise reduction of more than 3 dB is sufficient for residents to notice a positive change in acoustic environment [6]. For each noise mitigation device, in addition to calculating the average noise reduction value, the relationship between the speed of the moving train and the achieved reduction was analized. To explore the results in more detail, a division was made between different types of trains. Figure 1 shows an example of noise reduction results using rail absorbers for two types of trains: self-propelled passenger trains and wagon passenger trains. In both cases, the value of the noise reduction that occurs increases with increasing speed. The R^2 coefficients of the determined functions of the respective variables are 0.88 and 0.84, indicating a strong relationship between the discussed parameters. For self-propelled passenger trains, a more than twofold increase in noise reduction was observed with an increase in speed from 65 km/h to 110 km/h. For wagon passenger trains, an increase in speed from 65 km/h to 110 km/h resulted in a 1.9 dB reduction increase.

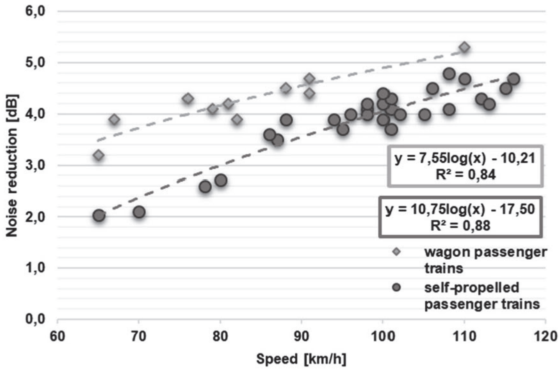

Figure 1 The relationship between noise reduction and the speed of passing trains at the location of rail absorbers

In addition, sound level measurements were made using 1/3 octave frequency bands filters. This approach enabled a more accurate analysis of the acoustic characteristics of the applied protection measures. Figure 2 presents the results of the selected noise mitigation, i.e. rail absorbers. The results shown in Figure 2 clearly indicate an improvement in the acoustic climate in the area of noise mitigation application. It can be seen that in the low-frequency range below 400 Hz there are lowest and even negative values. However, it needs to be mentioned that sounds at frequencies lower than 500 Hz and higher than 2,500 Hz can come from a variety of sources, such as people, animals, atmospheric conditions or other phenomena unrelated to railway traffic. The reduction in sound levels is particularly noticeable in the range from about 500 to about 2,000 Hz.

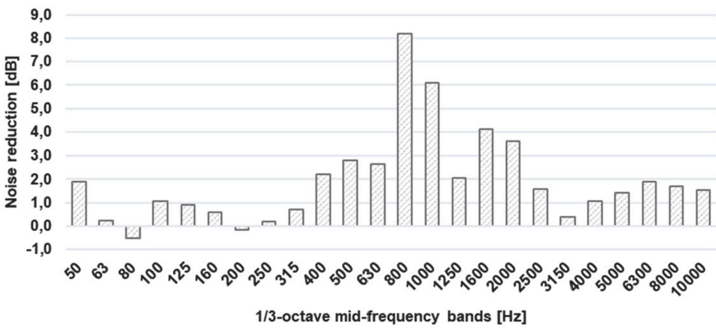

Figure 2 Noise reduction values for the frequencies of the middle 1/3 octave bands at the location of rail absorbers

4 Conclusions

The study discussed various approaches to reducing railway traffic noise, focusing on methods used in the area of track construction. According to the results, the most effective solution is the use of both under sleeper pads and rail dampers. This combination makes it possible to achieve the highest level of reduction, estimated at 4.8 dB. With this solution, it is possible to significantly improve acoustic conditions in the surroundings of the railway.

The implementation of noise mitigation measures in areas with noise exceedances is key to improving the quality of life of the local community. Therefore, detailed analyses should be carried out during the planning of railway infrastructure expansion investments with the aim of including appropriate noise reduction measures. Improving the acoustic climate could have a direct impact on reducing the negative consequences of noise on the health of local residents.

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